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HaloSat-RQMT-0002

Rev 17

HaloSat 6U CubeSat

NASA/GSFC Code 599

Mission Requirements Document (MRD) Level 1 and 2 Requirements

Goddard Space Flight Center
Greenbelt, Maryland

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National Aeronautics and Space Administration

HaloSat Requirements Document
Signature/Approval Page

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Preface

This document is a HaloSat Project signature-controlled document. Changes to this document require prior approval from HaloSat Configuration Control Board (CCB) Chairperson or designee. Proposed changes shall be submitted per HaloSat CM plan (HaloSat-PLAN-0004). Changes to this document will be made by complete revision.

All of the requirements in this document assume the use of the word "shall" unless otherwise stated.

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Change History Log

Revision	Effective Date	Description of Changes
-		Initial Release

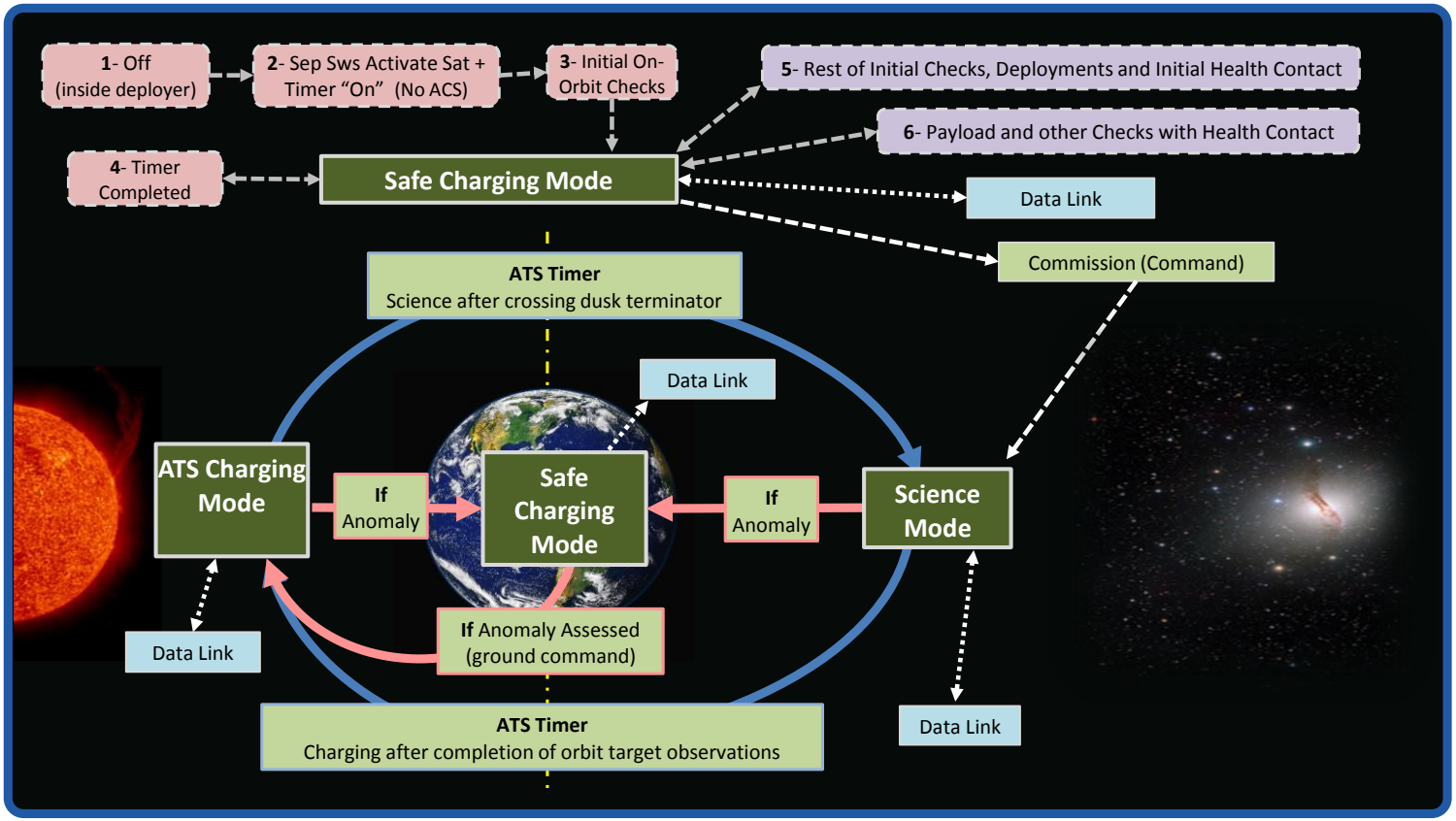
Requirement Types	Type	Qty	%	Comment
Allocation	A	0	0.00	Allocation from higher level. Examples: Mass, Power, alignment
Constraint	C	14	6.22	
Environmental	E	18	8.00	Environmental requirement
Functional	F	123	54.67	Functional requirement
Interface	I	17	7.56	Interface requirement
Performance	P	53	23.56	Performance requirement
Not A Requirement	NAR	N/A	N/A	Used for headings, lines added for readability, definitions, to cross reference applicable documents etc

Verification Methods	Method	Qty	%
Analysis	A	139	41.12
Demonstration	D	3	0.89
Inspection	I	66	19.53
Test	T	130	38.46

Req Terminology Definition	
Requirement	Shall
Good practice	Should
Permission	May/Can
Expectation	Will
Descriptive material	Is

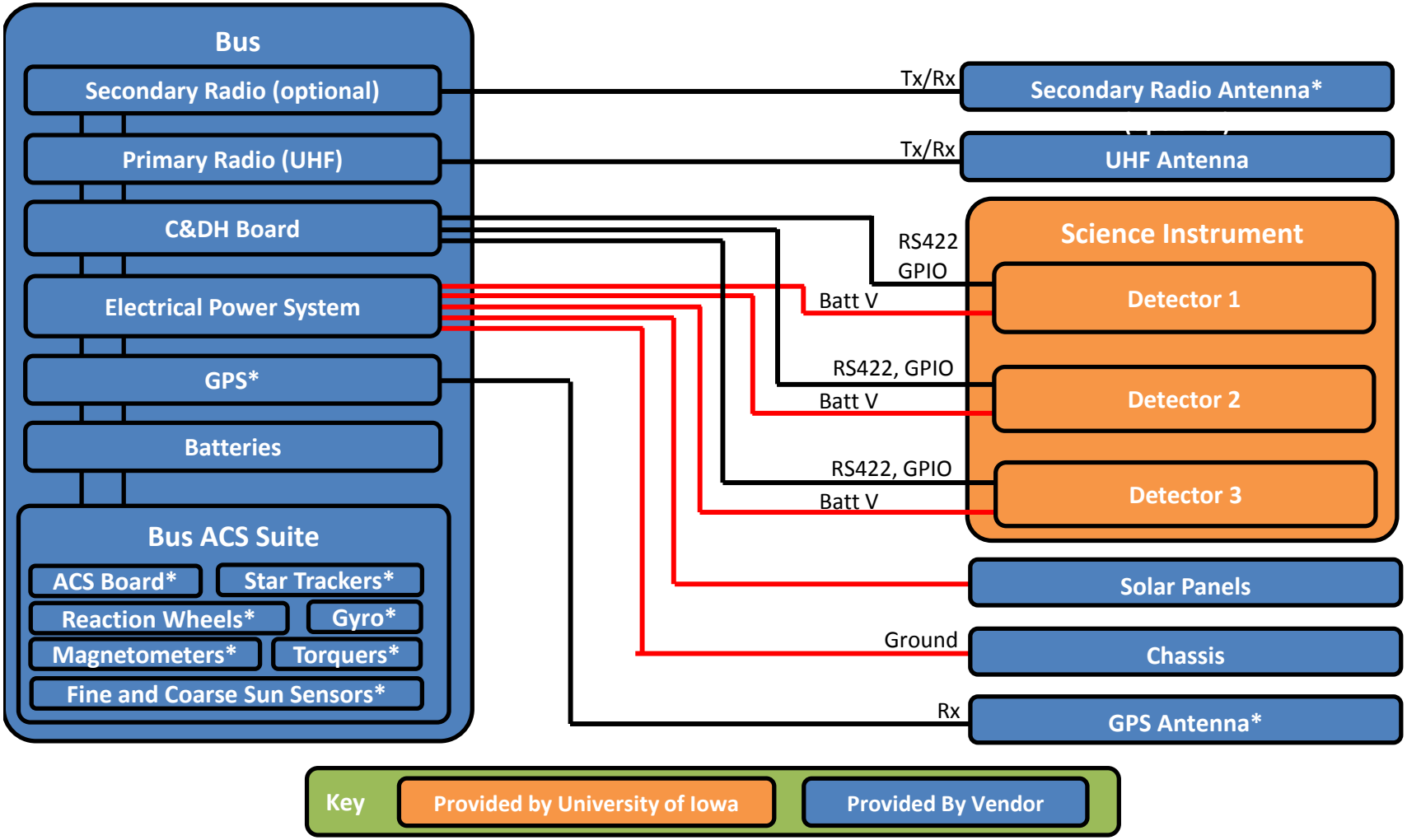
Mission Terminology Definition	
Bus	Spacecraft Bus (services not including science instrument)
Observatory	Spacecraft including bus and science payload
Payload	Science instrument
HaloSat	HaloSat project including hardware, software and people including flight and ground support

Acronyms	
ATS	Absolute Time Sequence
BDR	Baseline Data Requirements (Level 1 requirement)
BOM	Beginning of Mission
BTR	Baseline Technical Requirements (Level 1 requirement)
CCP	Contamation Control Plan
COP	Communications Operation Procedure
CPT	Comprehensive Performance Test
EOM	End of Mission
FWHM	Full Width Half Max
GDS	Ground Data System
GN	Ground Network
GPS	Global Positioning System
GSE	Ground Support Equipment
IOC	In Orbit Checkout
ICD	Interface Control Document
IRD	Interface Requirements Document
LV	Launch Vehicle
MOC	Mission Operations Center
NEN	Near Earth Network
OAP	Orbital Average Power
ODAR	Orbital Debris Assessment Report
PI	Principal Investigator
PLRA	Program Level Requirements Agreement (Level 1 Requirements Document)
RF	Radio Frequency
RTS	Relative Time Sequence
SOC	Science Operations Center
SOH	State of Health
TBD	To Be Determined
TBR	To Be Reviewed
ToO	Target of Opportunity
TVAC	Thermal Vacuum
UTC	Universal Time Coordinate
WGS	Wallops Ground Station



Mission Phase	Description
Pre-launch Operations	Ground testing and verification, end-to-end system verification and pre-launch planning
Timer	Phase covering deployer ejection to end of mandatory timer including checks
Commission	Phase covering deployments, additional checks, initial contact, bus checks, instrument checks and observatory commissioning
Science Operations	Phase covering nominal operation of HaloSat **Science Mode** – Instrument target pointing ACS configuration to obtain science. **Safe Charging Mode** – Also known as Safe Mode. Solar panels Sun pointing ACS configuration and obtain no science. Used during commissioning and anomalies (anomaly trigger in / ground command trigger out). **ATS Charging Mode** – Solar panels Sun pointing ACS configuration and obtain no science. Used every orbit to charge batteries during Sun lit half orbit (ATS trigger in/out). **(Optional, not shown in diagram) Antenna Pointing Mode** - Optional mode to obtain healthy link margin for downlink and uplink if necessary.
Disposal	End of mission. Disposal for this project means burn during re-entry. ODAR and demiseability analysis performed.

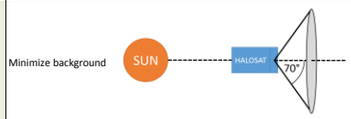
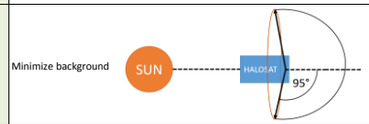
*Bus components are examples and will depend on vendor solution



Science objectives and goals	
ID	**Requirement**
Primary Science Objective	
OBJ-001	Measure the mass of the Milky Way's halo
Observational Goals	
N/A	Determine the geometry of the halo - is it extended or disk-like?
N/A	Measure how bright the halo is in soft X-rays

Level 1 Mission Requirements		
ID	**Requirement**	**Rationale**
MR1-001	X-ray detector shall be sensitive in a band from 400eV to 2,000 eV with <= 100 eV energy resolution at 600 eV	
MR1-002	The observatory shall observe at least 75% the sky with an angular resolution of 10° with goal to observe the whole sky	
MR1-003	The observatory shall obtain sufficient X-ray counts to measure the total emission in the sum of O VII and O VIII with a statistical accuracy of 0.5 LU for fields with a brightness of 5 LU (LU = line unit = photons/cm2/s/ster).	
MR1-004	Science observations will be planned to minimize magnetospheric, heliospheric, and particle backgrounds	

Vendor Applicability	ID	Requirement Title	Requirement	TBDs/TBRs	Type	Comments/Rationale	Parent Requirement ID	Verification Method				Verification Plan	Verification Procedure	Verification WOA Number	Verification Report Document Number	Verification Status
								A	D	I	T					
	MR2-10 Project-Wide Requirements				NAR											
√	MR2-10-001	Satellite Storage	HaloSat shall be able to stay in storage after observatory integration and testing is complete for a minimum of 5 years without significant degradation to performance with charging and periodical checks allowed		E	Launch date can move and the satellite shall be able to wait until an opportunity arises. Special requirements such as environmental requirements, battery charging, checks and minimal refurbishments could be allowed.		A				A - Assess if any component can be affected by long term storage and determine if special storage requirements are needed				
	MR2-10-002	Applicable USA Provider Documents	HaloSat shall be developed to be compliant with applicable requirements from the latest version of NR-SRD-029, CubeSat Design Specification (CDS), LSP-REQ-317.01 and Planetary Systems Corporation 2002367C		E	Available CubeSat related requirements. Compliance expands the launch possibilities.		A				A - Closure of all related lower level requirements				
√	MR2-10-003	Applicable NASA Documents	HaloSat shall be conducted in a manner compliant with NASA NPR 7120.8		E	Program and Project Management Requirements similar to those on suborbital projects such as sounding rockets		A				A - Closure of all related lower level requirements				
√	MR2-10-004	End of Mission	HaloSat shall meet the disposal orbit and space debris requirements in NPR 8715.6 and NASA-STD 8719.14		P	Requirement 6.2.14 from LSP-REQ-317.01 RevB	MR2-10-002	A				A - Orbital Debris (ODAR)				
√	MR2-10-005	Early Launch Date	The Observatory shall launch no earlier than January 2018		P	Driven by current funded schedule		A				A - Orbit Design A - Ground station availability A - Schedule revision as necessary				
√	MR2-10-006	Concept of Operations	The Observatory shall be designed and tested to be able to perform the HaloSat Concept of Operations per HaloSat-PLAN-0003		P	Satellite shall be able to perform the ConOps		A				A - Closure of all related lower level requirements				
√	MR2-10-007	Launch Approval Documentation Support	HaloSat project including spacecraft bus and payload team shall support any necessary documentation and analysis to get launch approval for potential safety hazards		F	Ensures commitment of the team and extended team to support hazard analysis/reporting				I		I - All necessary documentation and analysis for potential safety hazards are completed				
√	MR2-10-008	Hazardous Materials	CubeSat hazardous materials shall conform to AFSPCMAN 91-710, Volume 3		E	Requirement 3.1.7 from CDS Rev13	MR2-10-002	A				A - Verify HaloSat materials conforms to the standard				
√	MR2-10-009	Outgassing	CubeSat materials shall follow standard low out-gassing criterion to prevent contamination of other spacecraft during integration, testing, and launch of TMLs≤1.0% and CVCMs≤0.1%		E	Requirement 3.1.8 from CDS Rev 13	MR2-10-002	A				A - Verify HaloSat materials conforms to the standard				
√	MR2-10-010	Contamination Control	HaloSat shall follow any contamination control derived from spacecraft bus and payload cleanliness requirements per spacecraft bus team and Payload ICD HaloSat-ICD-0007		E	Requirement covers any known and unknown contamination requirements imposed by the payload or bus		A		I		A - Make sure proposed solutions are acceptable I - Inspect that proposed solutions are implemented				
	MR2-20 Risk Management, System Safety & Mission Assurance				NAR											
√	MR2-20-001	Accidental Damage	Flight and GSE HaloSat hardware will be designed and operated to prevent damage to personnel and flight hardware in both nominal and off-nominal situations		F	Do no harm philosophy to flight hardware and people		A				A - Constant evaluation of ongoing efforts to call out and react to designs and operations that can cause damage to personnel and flight hardware				
√	MR2-20-002	Safety Data Package	HaloSat shall provide and comply with all necessary information to pass a safety data package with launch provider		F	Ensures commitment of the team and extended team to support safety data package as needed				I		I - Inspect that a full safety data package was submitted and approved by launch provider				
√	MR2-20-003	Continuous Risk Management Program	HaloSat shall conduct a continuous risk management (CRM) program in compliance with GPR 7120.4D		F	Mainly for risk identification and tracking				I		I - Inspect that risk are being bookkept and tracked				
	MR2-30 Science				NAR											
	MR2-30-001	Photon Energy Level	The Payload shall detect photons within the 0.40 to 2.00 keV band		P	Defines the energy band of interest to comply with MR1-001	MR1-001	A			T	A - Over the entire band T - At key energies				
	MR2-30-002	Spectral Resolution	The Payload shall detect photons at a 100 eV energy resolution or better at 600 eV		P	Defines the energy resolution to comply with MR1-001	MR1-001	A			T	T - Test energy resolution for the measurement				
	MR2-30-003	Photon Count Rate	The Payload detector count rate shall be sufficient to be able to detect photons from the brightest, persistent soft X-ray source in the sky		P	Defines count rate to comply with MR1-003	MR1-003	A				A - Show that electrical design is capable of reaching acceptable count rate				
	MR2-30-004	Event Dead time	The Payload shall have an event dead time of less than 10% for the brightest, persistent soft X-ray source in the sky		P	Defines event dead time to comply with MR1-003	MR1-003	A				A - Time to process an event divided by the average time between events				
	MR2-30-005	Field of View	HaloSat shall observe at least 75% of the sky with an angular resolution of approximately 10° with a goal of observing 94% of the sky		P	Angular resolution needed from MR1-002	MR1-002	A		I	T	A - Show that 75% of the sky can be achieved with current ConOps A,I,T - Show compliance of the 10 degrees FOV with the design, inspection of parts and test?				
√	MR2-30-006	Science Operations Efficiency	The Observatory shall be able to perform 2 target observations per orbit		F	Amount of observations needed per orbit to achieve mission success in 183 days	MR1-003	A				A - Show compliance in ConOps A - Target planning A - Power budget				
√	MR2-30-007	Data Continuity	HaloSat shall provide to the PI at least 95% of the science data sent from the science instrument to the onboard computer, averaged over a 63-day cycle		P	Gives an acceptable limit for science data lost for different reasons based on 183 days of science with 2 detectors at 2 observations per orbit	MR1-002	A				A - RF downlink A - Ground Station Availability and ConOps				
√	MR2-30-008	Autonomous Pointing Duration	The Observatory shall point at a single science target for a minimum of 800 seconds per observation		P	Need to know pointing duration capabilities for design, integration, and testing	MR1-003	A				A - Spacecraft ACS analysis A - ConOps for duration plan A - Power budget				
√	MR2-30-009	Daily Science Data Collection	The Bus shall be designed to be capable of storing and transmitting at least 3 Megabytes per day of Science Payload data		P	Used to select appropriate bus and ground system solution	MR1-002	A			T	T - Spacecraft memory A - SOC planning implements this limit A - Data link budget				
√	MR2-30-010	Halo Targets Quantity	The Observatory shall point to a minimum of 300 predetermined halo science targets during the mission with a goal of 400 targets		P	Used for minimum success criteria. Minimum 300 targets needed to obtain an acceptable sky coverage	MR1-002	A				A - Target planning				
√	MR2-30-011	Observation Time Accumulation	HaloSat shall accumulate a minimum of 8,000 detector seconds of exposure per halo science target with a goal of 10,000 detector seconds		P	Used for minimum success criteria. Minimum 8,000 seconds needed to characterize a section of the sky	MR1-003	A				A - Target planning				
√	MR2-30-012	South Atlantic Anomaly	The payload shall ignore or not generate science data packets during passage through the SAA		C	Used to minimize background, from MR1-004	MR1-004	A			T	A - Target planning and/or T - on-board logic based on GPS position T - switch off instrument and/or high voltage with ATS and/or on-board logic				
	MR2-30-013	Halo Target Latitude	Halo targets shall be selected to cover the sky at ecliptic latitudes below 70°		C	Used minimize the background (foreground) from the Earth's magnetosphere	MR1-004	A				A - Target planning				
	MR2-30-014	Calibration Targets	The Observatory shall point to a minimum of 12 calibration targets during the mission with a goal of 24 calibration targets		F	Calibration targets are selected to study solar wind charge exchange (SWCX) emission in order to calibrate a model of SWCX emission used for HaloSat data analysis and also selected to study the response of the instrument. Approximately 5% of the total observing time will be devoted to these targets	MR1-004	A				A - Target planning A - Spacecraft ACS analysis/simulation				

√	MR2-30-015	Targets Orbit Constraint	The Observatory shall be able to perform halo science and calibration observations from dusk terminator to dawn terminator passing through midnight		F	Half portion of the orbit at the eclipsed side is used to minimize background	MR1-004	A			A - Target planning A - Spacecraft ACS analysis/simulation				
√	MR2-30-016	Calibration Target Orbit Constraint	The Observatory will be able to perform calibration observations at any point in the orbit		F	Allows for calibration out of the half orbit restriction to characterize the background	MR1-004	A			A - Target planning A - Spacecraft ACS analysis/simulation				
	MR2-30-017	Sun Angle for Science Target Selection	The Observatory shall only perform halo observations within a 70° cone of the anti-solar direction		C	Minimize background 	MR1-004	A			A - Target planning				
	MR2-30-018	Sun Angle for Calibration Target Selection	The Observatory shall only perform calibration observations within a 95° cone of the anti-solar direction		C	Minimize background 	MR1-004	A			A - Target planning				
	MR2-40 Systems Engineering & Observatory Requirements				NAR												
√	MR2-40-001	Mission Orbit Inclination	Orbit inclination shall be between 28 degrees and 60 degrees		C	Lower inclinations are preferred but ISS orbit works. Lower inclination will lower the background for the science instrument	MR1-004	A		I	A - Applicable analysis includes this range (ODAR, Power, Thermal, etc.) I - Manifested in desired orbit				
√	MR2-40-002	Mission Orbit Altitude	Orbit altitude shall be between 400 km and 600 km		C	LEO is better for CubeSats in general and ISS orbit increases launch opportunities		A		I	A - Applicable analysis includes this range (ODAR, Power, Thermal, etc.) I - Manifested in desired orbit				
√	MR2-40-003	Science Mission Duration	HaloSat shall achieve baseline science requirements in a maximum of 183 days after completion of in-orbit checkout		P	The baseline mission duration is predicted to be 1 month check-out phase plus a minimum 6 month science mission. Duration needed to cover an acceptable area in the sky	MR1-002	A		T	A - ConOps A - Target Planning A,T - Closure of all children hardware and ground segment and operations requirements				
√	MR2-40-004	Observatory Commissioning and Checkout	The Observatory shall operate on-orbit for a minimum of 213 days, including 30 days for on-orbit checkout		P	Checkout and commissioning phase timeline of 30 days. Could be refined after full definition of the system but 30 days is a good conservative estimate.		A	I	T	A,T - Closure of all children hardware and ground segment and operations requirements I - Operational Concept and Commissioning timeline fit within the 30 days				
√	MR2-40-005	Launch Vehicle IRD Compatibility	The Observatory shall be compatible with all LV operations, interfaces, and environments		I	The Observatory is required to fit within the static and dynamic envelopes of the fairing and comply with all mechanical and electrical interfaces		A		T	A, T - Instrument, Spacecraft and Observatory environmental analysis or test program, closure of lower level requirements				
√	MR2-40-006	Spacecraft Debris	All parts shall remain attached to the CubeSats during launch, ejection and operation		C	No additional space debris shall be created per requirement 3.1.2 from CDS Rev.13 and requirement 3.4 from NRCSD ICD Rev 0.36	MR2-10-002	A		T	A - Design and show that no debris is generated by the satellite T - Test deployments or any other functions that can potentially create debris				
√	MR2-40-007	Operational Modes Switch	The Observatory shall be capable of entering each operational mode per operations described on the Concept of Operations Document HaloSat-PLAN-0003		F	Requirement already covered on MR2-10-006 but called out specifically to verify/validate mode switching during test program				T	T - Test functions per ConOps				
√	MR2-40-008	PSC Requirements	HaloSat shall comply with all requirements for a 6U in the PSC Payload Specification Document (2002367C) unless otherwise specified in the HaloSat requirements document		I	Requirement used to specify it is a 6U CubeSat compliant with 6U requirement on the PSC document. Such document includes information for other U configurations	MR2-10-002	A			A - Show all lower level derived requirements are met				
√	MR2-40-009	CubeSat self-containment	The Observatory shall be passive and self-contained from the time it is loaded into the deployer during integration until after deployment on orbit		I	No charging of batteries, support services, and or support from ISS crew is provided after final integration. Original NanoRacks requirement: "The Observatory shall be passive and self-contained from the time it is loaded into the NRCSD for transport to the ISS and until after deployment from the deployer"	3.1 NRCSD ICD Rev 0.36	A		T	A - Show inhibit schematic to demonstrate passive design A - Show design for self containment T - Test system is passive and self-contained while inside deployer				
√	MR2-40-010	Observatory Shipping	The Observatory shall be delivered to final integration with deployer in a shipping case with the observatory monitored for shock to a minimum shock level based on the most sensitive component to help diagnose possible damage due to transportation		I	Gives us more information in case of a problem after shipping. Multiple shock monitors with different shock levels might be desired. Shock should be monitored at the SC level, not shipping container level.			I		I - Inspect delivery method for observatory				
√	MR2-40-011	External Interfaces	Observatory shall include external connections (umbilical) to provide electrical services which includes but it is not limited to battery charging, satellite external power, inhibits status, C&DH board access and radio RF access		F	Such connections are critical to the test program, especially TVAC campaign. It provides important connections with the physical flight configuration (no need to disassemble for access).		A	I	T	A - Show design includes such features I - Inspect features are build correctly T - Test umbilical for its intended function				
√	MR2-40-012	External Interfaces Access	Observatory shall place external connections to be accessible through access ports in deployer		C	Just in case access is needed after integration with deployer. Requirement 5.1.7 from NRCSD ICD Rev 0.36	MR2-10-002	A			A - Show that selected locations are clear for access				
√	MR2-40-013	Radioactive Material	HaloSat shall not contain radioactive material		C	Requirement 6.2.6 from LSP-REQ-317.01 RevB	MR2-10-002	A			A - Show the design does not include radioactive material				
√	MR2-40-014	Materials	HaloSat materials shall be selected in accordance with NASA-STD-6016 Section 4.2		C	Requirement 6.2.15 from LSP-REQ-317.01 RevB	MR2-10-002	A			A - Show materials selected comply with document				
√	MR2-40-015	Frangible Materials	A description of frangible materials (e.g. solar cells) must be provided to NanoRacks or applicable launch provider for approval		F	Requirement 3.6 from NRCSD ICD Rev 0.36	MR2-10-002		I		I - Inspect that such report is created				
√	MR2-40-016	Bill of Materials	HaloSat shall submit a Bill of Materials (BOM) to NanoRacks or applicable launch provider for assessment		F	Requirement 8 from NRCSD ICD Rev 0.36	MR2-10-002		I		I - Inspect that such report is created				
SE Obs	**MR2-41 Mechanical**				NAR												
√	MR2-41-001	HaloSat Mass	Observatory mass shall not exceed 12kg after final integration		P	PSC requirement (2002367C)	MR2-10-002	A		I	A - Keep healthy margins at each phase I - Measure observatory final mass				
√	MR2-41-002	Center of Mass	The stowed Observatory Center of Mass shall comply with the latest version of PSC specification document 2002367C		P	PSC requirement (2002367C)	MR2-10-002	A		I	A - Keep good CG estimates at each phase I - Measure observatory final CG location				
√	MR2-41-003	Pressure Vessels	Observatory shall not contain pressurized vessels		C	Requirement 6.2.4 from LSP-REQ-317.01 RevB	MR2-10-002	A			A - Show the design does not include a pressure vessel				

√	MR2-41-004	Locking Feature	Observatory shall use a secondary locking feature on fasteners		F	NanoRacks requires secondary locking features only for external fasteners but HaloSat project requires them on all fasteners. Requirement 3.5 from NRCSD ICD Rev 0.36	MR2-10-002	A		I		A - Show the design includes the feature I - Inspect drawings and parts for locking features				
√	MR2-41-005	Inhibits Switch Travel	Observatory separation from ejection plate necessary to change deployment switch state shall be between 1.3 and 12.7 mm		P	Requirement from PSC (2002367C)	MR2-10-002	A			T	A - Show switch and mechanisms selected complies T - Test engagement distance				
√	MR2-41-006	Tabs Material	Tabs shall be 100% continuous 7075-T7 aluminum alloy		I	Requirement from PSC (2002367C)	MR2-10-002	A		I		A - Show design has continuous tabs I - Inspect drawings and parts				
√	MR2-41-007	Tabs Coating	Tabs shall be Hard Anodized per MIL-A-8625, Type III, Class 1		I	Requirement from PSC (2002367C)	MR2-10-002			I		I - Inspect drawings and parts				
√	MR2-41-008	Tabs Length	Tabs shall run the entire length of the payload		I	Requirement from PSC (2002367C)	MR2-10-002			I		I - Inspect drawings and parts				
√	MR2-41-009	Dimensions Limits	Dimensions and tolerances shall be maintained under all temperatures and loading conditions		P	Requirement from PSC (2002367C)	MR2-10-002	A		I		A - Analysis to show dimension limits A - Analysis to show thermal effects A - Analysis to show external loads effects I - Inspect drawings and parts				
√	MR2-41-010	Pusher Plate Force	Observatory face on the pusher plate side shall be able to withstand 400 N force during launch due to vibration environment		P	Requirement from PSC (2002367C)	MR2-10-002	A				A - Show that force is used on mechanical analysis				
√	MR2-41-011	Observatory I&T Handling and Support Attachments	Observatory shall provide an interface for handling the hardware without damaging external components		I	Attachment points and handles might be needed to avoid damaging solar cells or any other exposed parts				I	T	A - Verification of interface T - Test of lift points				
√	MR2-41-012	Pyrotechnics	Observatory shall not contain pyrotechnics		C	Requirement 3.1.3 from CDS Rev13, 3.2 from NRCSD ICD Rev 0.36 and 6.2.7 from LSP-REQ-317.01 RevB	MR2-10-002	A				A - Show design does not contain pyrotechnics				
√	MR2-41-013	Dimensional Requirements	Observatory shall comply with all dimensional requirements per PSC 2002367C (Payload Specification Document)		P	Requirement from PSC (2002367C)	MR2-10-002	A		I		A - Analysis to show dimension limits I - Inspect drawings and parts				
√	MR2-41-014	Venting	Observatory and any enclosed volume inside the observatory shall be designed to accommodate ascent venting, per (ventable volume)/(ventable area) < 2000 inches		P	Requirement 3.1.11 from CDS Rev13	MR2-10-002	A				A - Analysis to show venting capability				
√	MR2-41-015	Deployables Constraint	Observatory deployables shall be constrained by the CubeSat, not the deployer		I	Requirement 3.2.4 from CDS Rev13	MR2-10-002	A				A - Show that some form of release mechanism is used for deployments				
√	MR2-41-016	Separation Switch Location	Observatory shall locate separation switches per PSC Payload Document (2002367C)		I	Requirement from PSC (2002367C)	MR2-10-002			I		I - Inspect switches location				
√	MR2-41-017	Table 1 Materials	Observatory shall use metals only from Table 1 of MSFC-STD-3029, waiver requires approval from HaloSat PM		I	Table 2 are possible but will require HaloSat PM approval		A				A - Show compliance with a delivery of a Bill of Materials				
SE Obs	**MR2-42 Power**				NAR					I		I - Verify the BOM				
√	MR2-42-001	Initial Stabilization	Observatory shall autonomously transition to a power positive state with all survival heater services powered after separation from the deployer		F	Do not want to deplete batteries while waiting for timer		A			T	A - Power budget analysis T - Spacecraft and Observatory testing				
√	MR2-42-002	Power Margins	Observatory shall be power positive at all Concept of Operations phases		P	Do not want to deplete batteries during normal operations		A				A - power budget analysis				
√	MR2-42-003	Science Payload Power Allocation	Observatory shall comply with Payload power requirements per Payload ICD HaloSat-ICD-0007		P	Requirement to define power ICD between bus and payload		A			T	A - power budget analysis T - Instrument and Observatory testing				
√	MR2-42-004	External Power	Observatory shall allow an external source to power the satellite during I&T		F	It is preferred if external power simulates solar panel (using the same interface and capability). Will be needed during extended testing such as TVAC since batteries will not contain enough energy.					T	T - Test if satellite is power positive with external power				
SE Obs	**MR2-43 Command and Data Handling**				NAR												
√	MR2-43-001	Payload/Bus Comm	The Payload and Bus shall be configured to communicate signals and data between them as specified in the Payload ICD HaloSat-ICD-0007		F	Requirement to define communication ICD between bus and payload					T	T - Test interfaces				
√	MR2-43-002	Commanding On-Board Housekeeping Data Storage	Observatory shall use an uploadable variable to autonomously either overwrite or stop collecting Housekeeping Data upon exceedance of on-board storage capacity		F	Depending on different circumstances, it may be beneficial to erase or stop collecting data upon exceedance. Nominal operations will not use all storage and comm capacity. This requirement is for the unlikely scenario that memory is full or a large part of it is corrupted and cannot be accessed.					T	T - Test feature				
√	MR2-43-003	Telemetry for Monitored and Updatable Data	Observatory shall be capable of providing telemetry defining the state of any quantity or function monitored or capable of being updated by the flight software		F	If a quantity of function is monitored, the bus should be able to provide such information. The same with quantities or functions that are capable to be updated to monitor its status.		A			T	A - Agree on telemetry to be recorded T - Test data is collected and recorded for download				
√	MR2-43-004	Required Functions	Observatory shall be capable of performing its required functions through the use of on-board stored operating programs, stored command sequences, and real-time commands radiated by the MOC		F	Requirement to make sure the satellite is able to operate autonomously taking certain decisions, through ATS/RTS and real-time or close to real-time commands from the ground.					T	T - Test capability				
√	MR2-43-005	Stored Commands - Absolute Time	Observatory shall upload, store, delete, replace and execute absolute time sequence commands for at least 28 days		F	Used make sure bus is capable of handling ATS and to define the minimum ATS size to be stored on-board.					T	Test of spacecraft ATS operations				
√	MR2-43-006	Stored Commands - Relative Time	Observatory shall upload, store, delete, replace and execute relative time sequence commands		F	Used to make sure bus is capable of handling RTS sequences					T	Test of spacecraft RTS operations				
√	MR2-43-007	Real Time Command Distribution	Observatory shall receive and distribute real-time commands sent from the ground		F	Requirement to make sure the observatory can be controlled from the ground as needed. Especially useful during troubleshooting and commissioning.					T	Observatory I&T test program send all spacecraft and instrument ground commands				
√	MR2-43-008	Payload Scripts Integration	Organization in charge of integration shall integrate provided payload scripts into the flight software segment		F	With instructions from the bus provider, the organization in charge of integration bus and payload should also integrate the software to interface with the payload				I	T	I -Inspect that scripts are provided to the organization in charge of I&T T - Proper implementation of scripts will be tested				
√	MR2-43-009	Observatory Mode Status	Observatory shall provide telemetry data to assess health status under all modes of operations		F	To monitor the observatory's health and status during all modes					T	Test program shall verify adequate instrument and Spacecraft telemetry for all operational modes				
√	MR2-43-010	Telemetry Collection	Observatory shall be able to store science and housekeeping telemetry for a minimum of 28 days		F	Need to collect and store Health and Safety telemetry during no-contact period for download during ground contacts.		A			T	A - Data storage analysis shows good margins over a 28-day period T - Test program shall verify storage and playback of instrument and Spacecraft telemetry				
√	MR2-43-011	Stored Telemetry Retransmission	Observatory shall delete or re-transmit stored telemetry to the ground on demand		F	The HaloSat system needs to allow the re-transmission of stored data in case the data is corrupted or lost during the initial transmission.					T	Test program shall verify re-transmit of instrument and Spacecraft telemetry MOC shall verify receipt of telemetry				
√	MR2-43-012	Commanding On-Board Science Data Storage	Observatory shall use an uploadable variable to autonomously either overwrite or stop collecting Science Data upon exceedance of on-board storage capacity		F	Same as requirement MR2-43-002 but for payload data. The setting could be different for science vs. housekeeping.					T	Closure of spacecraft requirements				

√	MR2-43-013	Reconfigurable Flight Software	Observatory flight software shall be reconfigurable on orbit		F	Flexibility is necessary to correct conditions that may not be known until after launch. Generic requirements. Details will be discussed with bus provider depending on existing capabilities.					T	Closure of spacecraft requirements				
√	MR2-43-014	Restart System	Observatory power system shall power cycle the entire spacecraft once a day during non-science periods		F	Just in case the satellite is malfunctioning and the bus is able to detect it. Power cycling spacecraft might clear single event upsets or similar situations.					T	Test program (TVAC) shall demonstrate this feature				
√	MR2-43-015	Deployment Timer	Observatory deployables including but not limited to booms, antennas, and solar panels shall wait to deploy a minimum of 30 minutes after the CubeSat's deployment switch(es) are activated from deployer ejection		F	Requirement 3.4.4 from CDS Rev13, 3.3 from NRCSD ICD Rev 0.36 and 5.1.1 from NRCSD ICD Rev 0.36	MR2-10-002		D		T	D - Lab demonstration of timer T - TVAC deployments including timer				
√	MR2-43-016	Operations During Timer	Observatory shall be allowed to operate during initial timers as long as there is no deployments and RF transmissions		C	Current understanding from launch providers but not officially on any requirements document.				I		I - Check if requirements about deployments and RF timers are met				
√	MR2-43-017	Timer Reset	Observatory timers shall be bypassed if the C&DH board is required to reboot during flight after initial timer and RF inhibits are successful		F	Waiting 30 minutes every time the spacecraft is power cycled on orbit could cause adverse effects. Such timer shall be bypassed after the spacecraft or ground contact acknowledges that initial timer after ejection from deployer has occurred.					T	T - TVAC reset showing timer is removed after initial completion				
√	MR2-43-018	Timer Bypass	Observatory initial 30-minute timer shall be able to be bypassed during ground testing as needed		F	Through the umbilical connection, ground testing shall be able to somehow bypass the timer if so desired.					T	T - Lab test showing bypass feature before I&T				
√	MR2-43-019	Timer Check	Observatory timer bypass feature shall be verifiable before fully integration with deployer		F	The project needs to have evidence available just in case launch provider requests prove that timer feature is engaged (bypass feature is inactive).			D			D - Lab demonstration on how to verify by-pass feature status				
SE Obs	**MR2-44 Thermal**				NAR											
√	MR2-44-001	Observatory Thermal Environment	Observatory shall be designed to withstand on-orbit thermal environment		E	Generic requirement to verify thermal analysis and testing is performed. Also requirement 7 from NRCSD ICD Rev 0.36. Observatory shall have enough temperature sensors to validate analysis assumptions on-orbit.	MR2-10-002	A			T	A - Parts selection to be able to withstand temperature range A - Thermal analysis to show positive margins for cold and hot orbits T - Thermal balance and Tvac testing to validate thermal analysis model and assumptions A - Perform an analysis between predicted temperatures and on-orbit temperatures for correlation				
SE Obs	**MR2-45 Communication**				NAR											
√	MR2-45-001	Stored Telemetry Transmission	Observatory shall transmit stored telemetry to the ground upon command from the ground		F	Need to Downlink collected and stored data and telemetry during ground contacts					T	Test program shall verify storage and playback of instrument and Spacecraft telemetry MOC shall verify receipt of telemetry				
√	MR2-45-002	Real-Time Telemetry Transmission	Observatory shall transmit real-time payload and spacecraft bus selected housekeeping telemetry at the beginning of every ground contact upon command from Ground Station		F	Need to downlink real-time data and telemetry during ground contacts to obtain a current snapshot of critical parameters to optimize pass limited time usage.					T	Test program shall verify storage and playback of instrument and Spacecraft telemetry Observatory level RF compact testing				
√	MR2-45-003	Transmission with all modes	Observatory will be capable of maintaining telemetry transmission at all different pointing and operational modes except for initial timer		F	Requirement is "will" and not "shall". Would like a SC solution that does not require antenna pointing. Omnidirectional capability might be achievable with secondary comm method.		A			T	A - Antenna Pattern analysis with acceptable coverage T - Test antenna pattern to confirm analysis				
√	MR2-45-004	Radio Reset	Observatory shall reset its communication system(s) if a command has not been received from the ground for a MOC-configurable length of time		F	This requirement calls out specifically one case of the FDC program. Reset may clear the problem. Length of time probably 28 days unless it is planned to have a pass off hours every so often to reset such counter.					T	T - Test feature during test program				
√	MR2-45-005	Internal Comm Error Detection	All Observatory internal communication shall include a type of error detection for data integrity		F	This could be as simple as a checksum. Should be a very basic addition (inexpensive) to help data integrity				I	T	I - Check code includes a standard form of error detection. T - If no standard form of error detection is used, then it shall be more thoroughly tested				
√	MR2-45-006	RF Licenses	HaloSat shall obtain and provide documentation of proper licenses for use of radio frequencies		F	Requirement 3.4.1 from CDS Rev13	MR2-10-002			I		I - Check that proper licenses were obtained				
√	MR2-45-007	RF Restrictions	HaloSat shall comply with United States radio license agreements and restrictions		F	Requirement 3.4.2 from CDS Rev13	MR2-10-002	A		I		A,I - Check that requirements were met				
√	MR2-45-008	RF Spectral Density	Observatory shall comply with power flux-density limits per Manual of Regulations and Procedures for Federal Radio Frequency Management (NTIA manual) section 8.2.36		F	NTIA RF radiation limit compliance		A			T	A - Power flux-density calculation T - Test antenna, radio and other parts of the system to validate power flux-density calculations				
√	MR2-45-009	RF Timer	Observatory shall not generate or transmit any signal from the time of integration into the deployer through 45 minutes after on-orbit deployment from the deployer		F	Requirement 3.4.5 from CDS Rev13	MR2-10-002	A			T	A - Show through schematics that we are compliant with 3 inhibits requirement T - Test 45-minute RF timer				
√	MR2-45-010	Forward Correction Capability	Primary radio shall include a form of forward correction capability		F	Capability present on the baseline radio used on the Wallops Ground Station				I	T	I - Check radio solution for proven forward correction capability. T - If no standard form of forward correction capability is used, then it shall be more thoroughly tested				
√	MR2-45-011	Beacon	HaloSat shall include a feature such as a beacon to locate the satellite in case of multiple CubeSat launches at the same time		F	Beacon is most likely needed if not launching from ISS to locate satellite, especially if launching multiple CubeSats at the same time. It may also serve to burst short messages as the beacon with some HSK data		A			T	A - Show it is in compliance with launch provider T - Test beacon functionality and RF timer compatibility				
√	MR2-45-012	Beacon on ISS	Satellite locator feature such as beacon may be removed for ISS launches to comply with ISS requirements if needed to comply with RF transmission safety		F	In case of ISS launch, the insertion vector and final TLEs are provided by NanoRacks, so no beacon is necessary. In case it is difficult to comply with ISS requirement for RF transmission and HaloSat requirement for beacon, HaloSat shall allow the beacon to be removable (detachable) as needed.		A			T	A - Show it is in compliance with ISS (ConOps, inhibits, etc.) T - Test beacon functionality and RF timer compatibility if used				
SE Obs	**MR2-46 Attitude Determination and Control**				NAR											
√	MR2-46-001	Inertial Target Pointing	Observatory shall point the Science Axis to ground-specified targets in celestial coordinates		F	The Observatory needs to point at Science Targets	MR1-002	A			T	A - ACS pointing analysis A, T - Closure of the Mission Pointing and Alignment Budget A - SOC planning of inertial targets T - Mission readiness test of SOC to MOC interface				
√	MR2-46-002	Observatory Pointing	Observatory shall be able to point within ±1.0° 3-sigma of the target position during the nominal science operations		P	Pointing includes capabilities and errors such as pointing knowledge and control. Pointing budget resides on HaloSat-PRES-0013.	MR1-003	A			T	Closure of Spacecraft ACS requirements				
√	MR2-46-003	ADCS On/Off	Observatory attitude control shall be capable of being enabled/disabled by a MOC command or command sequence		F	Capability needed to troubleshoot ADCS if not working properly.		A			T	A - All ACS items are switchable T - Test feature				
√	MR2-46-004	Torquer-Only Mode	Observatory may support a magnetic torquer only attitude control mode		F	Capability may be needed to troubleshoot ADCS if not working properly but Sun pointing may be required to keep positive power state		A			T	A - ACS pointing analysis T - Test ACS code				

√	MR2-46-005	Tip-off Rates	Observatory shall be able to recover from deployer tip-off rates after ejection		P	Use 2002337C Section 10 (PSC Canisterized Satellite Dispenser Data Sheet) for estimated tip-off rates. Time to stabilize shall be taken into account on the ConOps timeline (30 days for commissioning) and power positive requirement.		A			T	A - ACS analysis T - ACS simulation T - Test components to validate analysis and simulation				
√	MR2-46-006	Observatory Science Axis to Spacecraft Axis Knowledge	Observatory science axis to Spacecraft bus attitude control subsystem axis misalignment uncertainty shall be taken into account in the pointing budget		P	Pointing control and knowledge requirements are defined. These requirements shall take into account misalignment between science axis and ADCS axis. An alignment feature needs to be defined.					T	T - May require the use of an intermediate alignment feature (calibration of instrument to instrument feature, Bus ACS to ACS feature and ACS feature to instrument feature)				
√	MR2-46-007	Orbit Determination	On-board and on-the-ground position knowledge shall be designed to minimize the amount of time the instrument acts upon SAA passage		P	Requirement to derive position knowledge method (GPS, Ephemeris, etc.). Meant to be negotiated with bus provider.		A			T	A - Spacecraft orbit knowledge analysis T - Test of GPS receiver, ACS software or any other method used for orbit determination				
	MR2-50 Payload (Science Instrument)				NAR												
	MR2-50-001	Payload Simulator	The Payload team shall provide a simulator of the Payload to support System Integration testing as needed to the bus team and/or organization in charge of integration		F	Parallel effort to help schedule and reduce risk of eventually damaging flight hardware.				I	T	I - Inspect a simulator is provided and is representative of the flight module T - test power and data interface				
Payload	**MR2-51 Mechanical**				NAR												
	MR2-51-001	Science Payload Mass Allocation	Payload mass shall not exceed mass limit specified in the Payload ICD HaloSat-ICD-0007		P	Mass allocation for Payload		A		I		A - Keep healthy margins at each phase I - Measure observatory final mass				
	MR2-51-002	Science Payload CG	Payload shall conform to center of gravity location limits specified in the Payload ICD HaloSat-ICD-0007		P	CG allocation for Payload		A		I		A - Keep good CG estimates at each phase I - Measure observatory final CG location				
	MR2-51-003	Payload Volume	Payload shall not exceed volume per Payload ICD HaloSat-ICD-0007		P	Volume allocation for Payload		A	D	I		A - CAD volume I - Drawings, parts and assembly inspection D - Deployer fit check				
	MR2-51-004	Payload Packaging and Delivery	Payload shall be shipped to the spacecraft bus vendor appropriately packaged in a shipping container with the payload monitored for shock to a minimum shock level based on the most sensitive component to help diagnose possible damage due to transportation		I	Gives us more information in case of a problem after shipping. Multiple monitors at different shock levels might be desired. Shock should be monitored at the SC level, not shipping container level.				I		I - Inspect delivery method for payload				
Payload	**MR2-52 Power**				NAR												
	MR2-52-001	Instrument Power Use	Payload power shall not exceed power parameters such as Orbit Average Power and peaks per Payload ICD HaloSat-ICD-0007		P	Power requirements for Payload		A			T	A - Power consumption analysis T - Instrument and Observatory power testing				
	MR2-52-002	Power Switch Handling	Payload shall be capable of being powered on and off by the spacecraft bus at any time without causing degradation on performance		F	Instrument will be turned on/off repeatedly every day. There may be an on/off protocol to follow to avoid damaging components.					T	T -Payload level and observatory level testing				
Payload	**MR2-53 Command and Data Handling**				NAR												
	MR2-53-001	Payload On-Orbit Troubleshooting Data	Payload shall be able to acquire health, status and telemetry information from its instruments necessary for on-orbit troubleshooting from the ground		F	Just in case the payload is not working properly, we need enough information to assess the situation		A			T	A - Planning on important parameters to troubleshoot instrument T - Test telemetry of such parameters				
	MR2-53-002	Science Data Tag	Payload shall tag data packets with time and target pointing information		F	Tagging science data done by the instrument. This way the bus just has to store and transmit payload data. Time, PPS or similar may be needed from the bus					T	T - Payload and System level testing				
	MR2-53-003	Science Data Time-Tag Accuracy	Time tags in the science data shall enable reconstruction of event times to an accuracy of 2 seconds with respect to UTC		P	Time requirement is derived from the maneuver and observation time analysis		A			T	A - Analysis of scheme, reconstruction of event times T - key parameters for reconstruction are captured and tagged into science data				
Payload	**MR2-54 Thermal**				NAR												
	MR2-54-001	Thermal Limits	Payload shall remain within an acceptable temperature range at all times per Payload ICD HaloSat-ICD-0007		P	General requirement for a proper thermal design/test		A			T	A - Thermal analysis T - Verification of thermal analysis assumptions				
Payload	**MR2-55 Communication**				NAR												
	MR2-55-001	Comm Requirements	Payload shall comply with any communications requirements per Payload ICD HaloSat-ICD-0007		P	General requirement to define communication protocol between bus and payload		A			T	A - check comm selection compatibility T - Payload and system level tests				
Payload	**MR2-56 Attitude Determination and Control**				NAR												
	MR2-56-001	Payload Alignment Requirements	Payload shall provide a reference to be able to measure misalignment between instrument and spacecraft bus ACS		F	Such feature will be defined once the bus provider and I&T facility are selected. Such feature is needed to evaluate science and ADCS axis misalignment.		A			T	A - check compatibility of feature with organization in charge of integration T - Test alignment capability to feature				
	MR2-60 Spacecraft Bus				NAR												
√	MR2-60-001	SC System Characterization Report	Spacecraft bus team shall provide a system characterization report within 30 days after initial ejection from deployer		F	The spacecraft bus team will be considered experts on the bus system. This team should evaluate the performance of their system and report to the project within the commissioning phase.				I		I - Report is delivered including characterization of bus				
√	MR2-60-002	Track Changes	Spacecraft bus team shall track hardware and software changes and non-conformances and provide the data to the customer for review		F	Requirement to avoid late surprises or bus provider changes that could affect other areas.		A		I		A - Selection of a proper system I - inspection of data delivered				
√	MR2-60-003	Code Source	Spacecraft bus team shall notify NASA of the source of any code used by the bus		F	It is preferred to know the code source to determine if it can be trusted or not. Depending on the situation, NASA might perform software reviews to certain code.				I		I - Inspect information is provided				
√	MR2-60-004	Spacecraft Operator Handbook	Spacecraft bus team shall provide a Spacecraft Operator's Handbook providing information on the configuration and operation of the spacecraft		F	Handbook is necessary to operate bus system, minimizing bus provider interactions.				I		I - inspect document was provided and includes the information necessary				
√	MR2-60-005	SC Rules, Limits and Constraints	Spacecraft bus team shall provide detailed rules, limits and constraints for operation of the spacecraft		F	Operations team will be different that the bus provider. Rules, limits and constraints for operations are needed to ensure proper use of the SC				I		I - inspect document was provided and includes the information necessary				
√	MR2-60-006	Bus Fault Capabilities	Spacecraft bus team shall provide a detailed summary of the fault management capabilities of the Spacecraft, automated fault responses, fault monitor configuration, and responses		F	Failure detection and correction is a critical capability for any SC but CubeSats might be very limited in this regard. Details will be negotiated and documented.				I		I - inspect document was provided and includes the information necessary				
√	MR2-60-007	SC Bus Shipping	Spacecraft bus team shall deliver spacecraft bus system to organization in charge of integration in a shipping case with spacecraft bus monitored for shock to a minimum shock level based on the most sensitive component to help diagnose possible damage due to transportation		I	Gives us more information in case of a problem after shipping. Multiple shock monitors with different shock levels might be desired. Shock should be monitored at the SC level, not shipping container level.				I		I - Inspect delivery method for bus				
√	MR2-60-008	SC Bus Qualification	Spacecraft bus shall be subjected to all environmental testing described in this document for the observatory if observatory (spacecraft bus plus instrument) integration and testing is not performed by the spacecraft bus vendor		E	If observatory I&T is performed by anyone but the spacecraft bus team (vendor), the spacecraft bus shall be delivered fully qualified with testing such as comprehensive performance test, vibration and TVAC testing. If vendor is selected to provide I&T effort for the observatory, spacecraft bus qualification can be done at the observatory (spacecraft bus plus instrument) level.				I		I - Inspect if all appropriate testing was performed				
√	MR2-60-009	Payload Fit Check	Spacecraft bus team shall support a payload fit check with the spacecraft system		F	After delivery of a fully qualified bus, the bus provider will be involved in other activities. This requirement is one of those activities just in case their support is needed for a specific situation.				I		I - Inspect that bus team provide support as needed for a fit check				
SC Bus	**MR2-61 Mechanical**				NAR												

√	MR2-61-001	Spacecraft Bus Mass Allocation	Spacecraft bus mass shall not exceed 7 kg		P	Mass allocation for Bus		A		I		A - Keep healthy margins at each phase I - Measure observatory final mass				
√	MR2-61-002	Payload Volume Accommodation	Spacecraft bus shall be able to physically accommodate the science payload per Payload ICD HaloSat-ICD-0007		I	Bus volume accommodation for Payload		A		I	T	A - CAD model showing accommodations I - Drawing and parts inspections T - Fit checks				
√	MR2-61-003	Science Payload Mounting Interface	Spacecraft bus shall provide a mechanical interface between the Spacecraft bus and Science Payload per Payload ICD HaloSat-ICD-0007		I	The payload and Spacecraft elements will be assembled separately and mechanically connected at final integration.		A		I	T	A - CAD model showing accommodations I - Drawing and parts inspections T - Fit checks				
SC Bus	**MR2-62 Power**				NAR											
√	MR2-62-001	Power Switching	Spacecraft bus shall provide switched power to the Science Payload per the Payload ICD HaloSat-ICD-0007		F	Switching power is needed to turn off instrument as needed					T	T - Spacecraft and Observatory testing				
√	MR2-62-002	Bus Supplied Instrument Power	Spacecraft bus shall supply power to Payload per Payload ICD HaloSat-ICD-0007		F	Bus power accommodation for Payload					T	T - Spacecraft and Observatory testing				
√	MR2-62-003	Payload Harness	Spacecraft bus team shall provide power GSE and flight harnesses and cabling per Payload ICD HaloSat-ICD-0007		F	Payload provides 3 connectors for power. SC bus team should route such harnesses from these connectors to their counterparts on the bus side. SC bus team has a better understanding of routing.				I		I - Inspect proper harness was provided				
√	MR2-62-004	Battery Depth of Discharge	Spacecraft batteries shall be kept at an acceptable depth of discharge level for a 1 year life mission, for example below 20% (above 80% charge) for Li-Ion or Li-Polymer batteries		P	Based on previous experiences and conversation with Li-Ion and Li-Polymer battery suppliers, 20% depth of discharge is highly desirable to extend battery life. For missions under 1 years, 25% could be acceptable depending on the battery and project risk posture.		A				A - power budget analysis				
√	MR2-62-005	Energy Stored	Total stored chemical energy capacity should not exceed 79 Watt-Hours		P	This requirement is not a "shall" but a "should". If 79 Wh is exceeded, a thermal runaway test will have to be performed. This test will add complications to schedule and cost but could be done if needed. Requirement 3.1.6 from CDS Rev13 asks for 100 Wh or less because it could limit launch opportunities.	MR2-10-002				T	T - Test battery capacity				
√	MR2-62-006	Inhibits Quantity	Spacecraft bus shall contain 3 independent means of power inhibit while sitting inside deployer actuated by independent physical deployment switches per figure 12 of NRCDS ICD Rev 0.36		F	The satellite needs to be inhibited in 3 places to avoid any inadvertent powering of the satellite. Requirement 4.7.1 from NRCSD ICD Rev 0.36, 5.1.2 from NRCSD ICD Rev 0.36 and 3.3.9 from CDS Rev13.	MR2-10-002	A		I	T	A - Schematics I - Inspection of hardware per schematics T - Test features				
√	MR2-62-007	Inhibits During Launch	Observatory shall return to pre-launch state if mechanical switches toggle from the actuated state and back during launch including reset of any timers		F	Requirement 3.3.5 from CDS Rev13 and 3.3 from NRCSD ICD Rev 0.36	MR2-10-002				T	T - Toggle switch and verify requirement				
√	MR2-62-008	Inhibits Life	Observatory shall remain off while inside the deployer from integration to deployer until separation at time of deployment		F	Requirement to establish that after integration with deployer, the satellite is not allowed to be removed from the deployer		A				A - Schematic showing satellite powered off while inside deployer including physical contact. Feature tested on MR2-62-006				
√	MR2-62-009	Remove Before Flight	Observatory shall include a remove before flight feature to disable satellite power from the batteries during ground handling		F	Requirement 5.1.4 from NRCSD ICD Rev 0.36	MR2-10-002				T	T - Test RBF keeps satellite off during ground handling				
√	MR2-62-010	ISS Power Safety Requirements	Observatory systems including batteries and power system shall comply with all necessary ISS safety requirements for ISS CubeSat deployments		P	Requirements include but not limited to testing at different levels and 2 layers of protection circuits (over voltage, over current and under voltage). Requirement 5.2 from NRCSD ICD Rev 0.36.	MR2-10-002	A		I	T	A- Schematics I - Inspection of features implementation T - test per ISS requirements				
√	MR2-62-011	Inhibits Force	Inhibits shall exert less than 4 pounds of force total when fully engaged		P	PSC requirement allows a much lower maximum force. Per email conversations with PSC, the satellite for a 6U is allowed up to 4 lbs. The lower requirement is for 3U satellites.	MR2-10-002				T	T - Test inhibits switches force				
√	MR2-62-012	Remove Before Flight Charging	Remove before flight feature shall preclude any power from any source operating any satellite functions with the exception of pre-integration battery charging		F	Requirement 5.1.5 from NRCSD ICD Rev 0.36	MR2-10-002				T	T - Test power isolation and ability to charge batteries with RBF				
√	MR2-62-013	Remove Before Flight Placement	Remove before flight feature shall be able to remain in place during integration with deployer		F	Requirement 5.1.6 from NRCSD ICD Rev 0.36	MR2-10-002	A		I		A - Show in CAD the RBF feature doesn't have to be removed I - Check protruding dimensions for RBF feature to make sure it can remain on the satellite during integration with deployer				
√	MR2-62-014	Energy stored over 80Wh	Additional ISS related tests including thermal runaway test shall be performed if chemical energy stored capacity is equal to or exceeds 80 Watt-hours		F	Requirement from experience and conversations with JSC/ISS.					T	T - verify testing is done if energy exceeds the amount				
√	MR2-62-015	Default RBF Use	Remove before flight feature shall be used when charging batteries by default unless external power is also intended to be used to power spacecraft bus		F	In case batteries need to be charged without the need to turn on the observatory		A			T	A - RBF allows charging T - RBF allows charging (while activated) and allows external power on of the satellite (while deactivated)				
√	MR2-62-016	Inhibits Bypass	Spacecraft bus shall have a deployer accessible feature to disable inhibits	Added	F	This feature allows the satellite to bypass inhibits and turn on the satellite using battery or external power. Could be useful for checks after integration with deployer.		A			T	A - Schematic showing bypass feature functionality T - Test feature functionality before and after environmental test				
SC Bus	**MR2-63 Command and Data Handling**				NAR											
√	MR2-63-001	Payload Comm Harness	Spacecraft bus team shall provide communication GSE and flight harnesses and cabling per Payload ICD HaloSat-ICD-0007		F	Payload provides 3 connectors for comm. SC bus team should route such harnesses from these connectors to their counterparts on the bus side. SC bus team has a better understanding of routing.				I		I - Inspect proper harness was provided				
√	MR2-63-002	Telemetry Monitoring	Spacecraft bus shall monitor selected telemetry for on board fault detection and correction which includes but it is not limited to battery voltage, individual power switches current and critical components temperatures.		F	This requirement is derived from the need to have knowledge of observatory telemetry to aid in post-processing and/or troubleshooting					T	Test of spacecraft FDC safing features Test of instrument internal safing features/closure of children instrument requirements Test of Spacecraft bus safing features/closure of children Spacecraft requirements				
√	MR2-63-003	Fault Protection	Spacecraft bus shall take corrective action upon fault detection		F	To protect the observatory from catastrophic electrical and attitude faults where applicable					T	Test of spacecraft bus safing				
√	MR2-63-004	Science Data Collection Rate	Spacecraft bus shall be able to handle Science Payload Science Data rates per Payload ICD HaloSat-ICD-0007		P	The observatory needs to collect and store Science Data at an adequate rate to capture all the Payload Data					T	Closure of spacecraft, instrument and SOC planning requirements				
√	MR2-63-005	Science Payload State of Health Data Collection Rate	Spacecraft bus shall store Science Payload State of Health (SOH) Data per Payload ICD HaloSat-ICD-0007		P	The observatory needs to collect State of Health Data at an adequate rate to capture all Payload telemetry					T	Closure of spacecraft, instrument and SOC planning requirements				
√	MR2-63-006	PPS Signal	Spacecraft bus will provide the payload with a 1PPS signal for clock synching purposes as specified in the Payload ICD HaloSat-ICD-0007		P	Requirement is a "will" not a "shall". Payload prefers PPS but other forms to comply with UTC 2 second post-processing time accuracy for science data time tag may be acceptable.					T	Test bus provides PPS to Instrument				

√	MR2-63-007	Autonomous Science Mode Operation Duration	The spacecraft bus shall be designed to store and execute a minimum of 28 days of science mode commands		F	Need to have sufficient sequence storage capability to avoid frequent uplinks to the spacecraft and efficient target observation planning to reduce ground contacts and product generation costs		A			Spacecraft, MOC and SOC requirements will support the products and this operational cadence. A - ATS sizing A - SOC planning for maximum number of commands in a 28 day sequence. Then, MOC / Spacecraft verifies the integrated ATS (including MOC and SOC commands included) fit inside the allocated Spacecraft ATS buffer				
√	MR2-63-008	Deployment Status	Spacecraft bus shall monitor and record the status of the electromechanical deployments		F	Confirmation that deployables worked as expected. Helps troubleshoot possible problems				T	T - Observatory deployment test verifies telemetry availability				
√	MR2-63-009	Spacecraft Bus to Payload Commands	Spacecraft bus shall buffer and relay commands to the Science Payload as received from the ground		F	Payload may have to be commanded from the ground, especially during a payload troubleshooting scenario.				T	Closure of spacecraft requirements				
√	MR2-63-010	Main Computer Watchdog	Spacecraft bus main computer shall include a watchdog feature to restart computer in case it is not responding		F	Automatic action to unresponsive C&DH board. Fairly standard on CubeSat C&DH boards.		A		T	A - Show how the watchdog works in theory T - If possible, test functionality				
√	MR2-63-011	Software Development Process	Spacecraft bus team shall maintain a documented software development process		F	Helps organize the effort and reporting to HaloSat management			I		I - Inspect documented process				
√	MR2-63-012	Software Configuration Management	Spacecraft bus team shall have a software configuration management process		F	Helps organize the software development effort with revision control			I		I - Inspect if CM process exists and is adequate				
SC Bus	**MR2-64 Thermal**				NAR										
√	MR2-64-001	Science Payload Thermal Interface	Spacecraft bus shall provide a thermal interface between the Spacecraft bus and Science payload to keep payload at an acceptable temperature range per the Payload ICD HaloSat-ICD-0007		I	The observatory shall survive all thermal conditions per MR2-44-001 but this requirement calls out specifically the Payload interface.		A	I	T	I - Check interface is done per spec A - Thermal analysis should show compliance with acceptable temperature range T - thermal balance test to validate thermal model				
SC Bus	**MR2-65 Communication**				NAR										
√	MR2-65-001	Link Margin	The observatory shall maintain a link margin greater or equal to 2 db with the Ground Station when in its view		P	Link analysis can/will be done with the highest gain on the antenna pattern. Will have to show compliance by pointing antenna or antenna pattern with ConOps		A			A - Link analysis				
√	MR2-65-002	Normal Ops. Downlink Capability	Spacecraft-to-Ground Station Network nominal downlink shall be designed to be able to download all science and housekeeping data produced over the mission lifetime		P	ConOps, radio download speed and other factors shall be taken into account to show all data can be obtained.		A		T	A - Data budget T - Closure of spacecraft requirements				
√	MR2-65-003	Safe mode Downlink Capability	Spacecraft-to-Ground Station Network safe mode downlink shall be designed to be able to download safe mode state telemetry		P	Safe mode may require a higher housekeeping data production to investigate a problem.				T	Closure of spacecraft requirements				
√	MR2-65-004	Uplink data rate	Spacecraft bus shall be designed to be able to receive all necessary uplink tables and commands		P	ConOps, radio upload speeds and other factor shall be taken into account to show all data can be uploaded.				T	Closure of spacecraft requirements				
√	MR2-65-005	Primary Uplink Frequency Band	Primary method of communication uplink frequency shall be selectable with a 10 MHz range including 450 MHz with at most 100 Hz steps		F	Frequency guarantees compatibility with Wallops ground station		A		T	A, T - Closure of lower level spacecraft and SOC requirement T - Observatory level I&T RF compatibility test.				
√	MR2-65-006	Primary Downlink Frequency Band	Primary method of communication downlink frequency shall be selectable with a 10 MHz range including 468 MHz with at most 1 MHz steps		F	Frequency guarantees compatibility with Wallops ground station		A		T	A, T - Closure of lower level spacecraft and SOC requirement T - Observatory level I&T RF compatibility test.				
√	MR2-65-007	Memory Content Transmission	Spacecraft bus shall be capable of transmitting any or all of its memory contents on command by MOC		F	First In First Out (FIFO) scheme is acceptable.				T	T - TVAC comm test T - end to end comm test				
√	MR2-65-008	Command Confirmation	Spacecraft bus shall indicate receipt and execution of all commands and command sequences in telemetry to the MOC		F	Need a form of confirmation for uploads.				T	T - Test MOC receives confirmation				
√	MR2-65-009	Primary Method of Communications	Primary method of communication to and from the Observatory during normal operations shall use Wallops UHF ground station		F	Defines the primary method for transmitting commands and receiving telemetry from the Observatory		A		T	A, T - Closure of lower level spacecraft and SOC requirement T - Observatory level I&T RF compatibility test.				
√	MR2-65-010	Secondary Method of Communications	Observatory may use a secondary method of communication to and from the Observatory as needed with a minimum of 40% coverage over an ISS orbit, such as GlobalStar (LinkStar) and Iridium		F	Requirement uses "may" instead of "shall". Secondary method of communication is desirable but not required. Defines the secondary method for transmitting commands and receiving telemetry from the Observatory		A		T	A, T - Closure of lower level spacecraft and SOC requirement T - Observatory level I&T RF compatibility test.				
√	MR2-65-011	Secondary Method of Communication Uplink	Observatory shall be capable of utilizing the secondary method of communication for uplink during nominal and contingency operations if so equipped		F	Secondary method uplink capability needed if secondary method is selected.		A		T	A, T - Closure of lower level spacecraft and SOC requirement				
√	MR2-65-012	Secondary Method of Communication Downlink	Observatory shall be capable of utilizing the secondary method of communication for downlink during nominal and contingency operations if so equipped		F	Secondary method downlink capability needed if secondary method is selected.		A		T	A, T - Closure of lower level spacecraft and SOC requirement				
√	MR2-65-013	Primary Receive Mode	Spacecraft bus primary receiver shall be continuously receptive to commands from the ground		F	Using a location filter for Wallops can be useful for security purposes but in case Wallops Ground Station is down, we could use an alternate location.		A		T	A - define a scheme to make sure receiver is always receptive T - test receive mode				
√	MR2-65-014	Ignore Bad Incoming Data	Spacecraft bus shall ignore commands that are improperly formatted or contain packet errors		F	Form of security and error detection to ensure proper communication				T	T - comm test				
SC Bus	**MR2-66 Attitude Determination and Control**				NAR										
√	MR2-66-001	Slew Rate	Spacecraft shall slew and settle the Observatory between inertial targets up to 180 degrees apart within 200 seconds		P	The requirement is driven by the ability to acquire the targets needed per orbit within the half orbit time limit		A		T	Closure of Spacecraft ACS requirements				
√	MR2-66-002	Propulsion	Spacecraft bus shall not contain propulsion systems		C	Requirement 3.2.5 from LSP-REQ-317.01 RevB	MR2-10-002	A			Verify the design does not include a propulsion system				
√	MR2-66-003	Bus Alignment Requirements	Spacecraft bus shall provide a reference to be able to measure misalignment between instrument and spacecraft bus ACS		F	Such feature will be defined once the bus provider and I&T facility are selected. Such feature is needed to evaluate science and ADCS axis misalignment.		A		T	A - check compatibility of feature with organization in charge of integration T - Test alignment capability to feature				
√	MR2-66-004	Bus Pointing Allocation	The maximum bus pointing allocation including knowledge and control errors to the ACS alignment feature is +/-0.30° or +/-18 arcmin		F	This allocation is derived in HaloSat-PRES-0013. It reduces the +/-1° pointing requirement by the payload errors and measurement errors between the payload and ACS alignment features.	MR1-003	A		T	Closure of Spacecraft ACS requirements				
	MR2-70 Ground Segment & Mission Operations				NAR										
√	MR2-70-001	Scheduling Activities	Number of passes per day and its duration shall be predicted 14 days in advance for staffing purposes		F	To give a reasonable amount of time to the SOC and MOC to plan for the passes (target definition, staffing, etc.)		A			A - Devise a method to predict number of passes and durations showing acceptable results				
	MR2-70-002	WGS to SC ICD	Wallops Ground Station team shall document the spacecraft to ground station ICD defining space to/from ground data interfaces		F	Giving responsibility to Wallops Ground Station to provide the WGS ICD to the satellite			I		I - Inspect ICD is provided				
	MR2-70-003	WGS to MOC ICD	Wallops Ground Station team shall document the ground station to MOC ICD defining ground station to/from MOC data interfaces		F	Giving responsibility to Wallops Ground Station to provide the WGS ICD to the MOC			I		I - Inspect ICD is provided				

	MR2-70-004	MOC and GDS Operational Lifetime	MOC and ground data system shall be designed to have an operational lifetime to support all phases of the mission		F	Ensures MOC, SOC and ground station are properly funded		A				A - Show proper planning of MOC and ground data system				
	MR2-70-005	Orbit Parameters Generation	MOC shall generate and deliver any necessary orbit data needed for scheduling and antenna pointing		F	MOC is responsible to obtain and deliver necessary information to the WGS to point the antenna and scheduling		A				A - show that MOC can generate such information. May depend on bus solution.				
	MR2-70-006	Payload Activity Request Incorporation	MOC will incorporate Payload PI activity requests into daily command pass activities		F	SOC/PI may need/have specific requests and MOC shall try to incorporate such requests if physically possible		A				A - Verify ability of MOC to incorporate Payload PI activities. Ongoing during mission.				
	MR2-70-007	Command and TLM Database Creation	MOC shall be involved in the spacecraft bus team creation and implementation of the command and telemetry database used by organization in charge of integration for integration and test of the avionics and the spacecraft		F	MOC needs to be involved since ultimately it will be the spacecraft operator		A		I		A - Plan involvement I - Inspect MOC involvement				
	MR2-70-008	Ground Segment Commanding Path	Ground Segment shall transmit Observatory commands from the MOC to the Observatory through the Wallops ground station and/or optional secondary communication method		F	Defines the data path including the ground station for uplink					T	Test of MOC requirements				
	MR2-70-009	Ground Segment Telemetry Path	Ground Segment shall relay Observatory data to the MOC from the Observatory through the Wallops ground station and/or optional secondary communication method		F	Defines the data path including ground station for downlink					T	Test of MOC and SOC requirements				
	MR2-70-010	Voice Networks	Ground Segment shall provide voice networks for mission operations		I	Needed to support mission from pre-launch through mission disposal. MOC and WGS need to be in real-time voice communication during the passes.					T	Test of MOC requirements				
	MR2-70-011	MOC I&T Support	MOC shall support I&T phase as needed		F	MOC will be used to communicate with the satellite on-orbit and during testing.		A		I		A - Plan involvement I - Inspect MOC involvement				
	MR2-70-012	Observatory Data Storage Volume Planning	Ground Segment shall provide target observations planning and downlink scheduling to ensure on-board data storage is not exceeded prior to the next scheduled downlink		F	Mitigates the risk that the onboard storage capacity is exceeded by proper planning of target observations and scheduling downlinks		A			T	Verification of MOC planning requirements				
	MR2-70-013	Downlink Data Availability	Ground Segment shall make available to the MOC and SOC stored downlinked raw science data and housekeeping data for processing within 1 day of transmission to the ground		P	Deliver data in a timely manner for measurement data processing, ensures ground can deliver data without backlog, and to check the status of the Observatory every day		A			T	Verification of MOC and SOC requirements				
	MR2-70-014	Data Processing Documentation	PI shall deliver all instrument science data files, calibration files, and software required for analysis of the instrument science data to HEASARC within 5 months from the mission completion		P	Defines the time period within the raw science data is delivered for distribution		A			T	Verification of SOC requirements				
	MR2-70-015	Mission Data Long Term Storage	PI shall deliver the final, fully-calibrated HaloSat instrument science data set, the high-level science data products, and documentation and software required for analysis of the science data to HEASARC within 5 months from the mission completion		P	Defines the time period within the final/calibrated science data is delivered for distribution		A			T	Verification of SOC requirements				
	MR2-70-016	Final Science Data Public Availability Time Period	HEASARC will make the final, fully-calibrated HaloSat instrument science data set and the high-level science data products available to the public within 1 month of their delivery from the SOC		P	Defines the time period within the science data is made available to the public				I		Any agreements, contracts?				
	MR2-70-017	Mission Housekeeping Storage at MOC	MOC shall archive all the HaloSat downlinked housekeeping data (real-time and playback) for the life of the mission		F	Defines the MOC requirement to archive the HaloSat housekeeping data		A			T	Verification of MOC requirements				
	MR2-70-018	Housekeeping Telemetry Processing at MOC	MOC shall process all the HaloSat downlinked housekeeping data (real-time and playback)		F	Defines the MOC requirement to process the HaloSat housekeeping data		A			T	Verification of MOC requirements				
	MR2-70-019	Support of Routine HaloSat Contacts	MOC shall provide support of routine HaloSat ground station contacts		F	Support is needed for pass planning		A			T	Verification of MOC requirements				
√	MR2-70-020	Bus Operational MOC Support	Spacecraft bus team shall provide 24/7 on-call MOC support for 1-month of on-orbit operation of the spacecraft		F	Spacecraft bus team support may be needed any time during the commissioning phase (on-call means remote support as needed)				I		Support is included in agreement and is properly funded				
√	MR2-70-021	Bus Anomaly MOC Support	Spacecraft bus team shall provide on-call MOC support to help investigate and solve on-orbit anomalies during the entire mission length		F	Spacecraft bus team support may be needed occasionally during the rest of the mission (on-call means remote support as needed)				I		Support is included in agreement and is properly funded				
√	MR2-70-022	GDS Simulator for MOC	Spacecraft bus team should provide a ground data system simulator to the MOC to allow for interface testing and verification of command, telemetry, and scheduling products		F	Requirement is "should" instead of "shall". It is desired to have a bus simulator for parallel activities between bus and MOC				I		Inspect a simulator was delivered				
√	MR2-70-023	Bus Simulator for MOC	Spacecraft bus team should provide MOC a spacecraft simulator for MOC testing and command validation during I&T and the flight phase of the mission		F	Requirement is "should" instead of "shall". It is desired to have a bus simulator during I&T for parallel activities between bus and MOC				I		Inspect a simulator was delivered				
√	MR2-70-024	I&T Scripts	Spacecraft bus team shall provide I&T test scripts and procedures to the MOC		F	Spacecraft bus team is responsible for providing the MOC with scripts necessary to test the spacecraft bus during I&T				I	T	I - Inspect delivery of scripts T - Test scripts as lower level requirements are fulfilled				
√	MR2-70-025	Ground Station Interface	The Observatory and MOC shall be compatible with existing Wallops Ground Station equipment for its primary method of communication per Wallops Ground Station ICD		F	Ensures compatibility with WGS		A			T	A, T - Closure of lower level spacecraft and SOC requirement T - Observatory level I&T RF compatibility test.				
	MR2-70-026	Ground Pass Prediction	Number of passes per day and its start/end time shall be predicted at least 2 days in advance for pass planning purposes with a +/-10 second accuracy		P	Requirement MR2-70-001 establishes 14 days for staffing purposes. This requirement establishes at least 2 days for implementation purposes										
	MR2-80 Environments, Integration, Testing, Verification and Validation				NAR											
√	MR2-80-001	Launch Vehicle Environmental Requirements	HaloSat shall comply with testing per LSP-REQ-317.01 Rev B Table 1		E	This document table specifies tests, duration and levels for Random Vibe, Sine Vibe, Shock and Bakeout. Maximum predicted environment is not defined. Requirement per Table 1 from LSP-REQ-317.01 RevB	MR2-10-002	A			T	A, T - Instrument, Spacecraft and Observatory environmental analysis or test program, closure of lower level requirements				
√	MR2-80-002	Strength Qualification Requirements	Strength qualification requirements shall be per LSP-REQ-317.01 RevB Table 2		E	Requirement per Table 2 from LSP-REQ-317.01 RevB	MR2-10-002	A			T	A, T - Instrument, Spacecraft and Observatory environmental analysis or test program, closure of lower level requirements				
√	MR2-80-003	Maximum Predicted Launch Random Vibration	HaloSat shall be tested to random vibration levels specified by launch provider, specified by HaloSat project or specified in the Goddard Environmental Verification Standard (GEVS) document at HaloSat's project management direction		E	Requirement to test survivability of launch loads	MR2-10-002	A			T	A, T - Instrument, Spacecraft and Observatory environmental analysis or test program, closure of lower level requirements				
√	MR2-80-004	Deployer Integration Requirements	HaloSat shall include HaloSat specific integration requirements in memo format along with the CubeSat for integration		F	Requirement 9 from NRCSD ICD Rev 0.36	MR2-10-002			I		I - Inspect such document is created as needed				
√	MR2-80-005	CPT Before and After Environmental Testing	Components, subsystems and systems with their functions shall be tested as flight-like as possible in a comprehensive performance test at minimum before and after environmental testing		E	Required to verify proper functionality of the spacecraft after simulated launch environment		A			T	A, T - Instrument, Spacecraft and Observatory analysis or test program, closure of lower level requirements				
√	MR2-80-006	End-to-end Comm Test	Spacecraft bus team shall perform an integrated end-to-end test of the Observatory and MOC with the Wallops Ground Station to validate commanding and telemetry		F	Test to verify proper functionality of the ground system in a flight-like configuration		A			T	A, T - Instrument, Spacecraft and Observatory analysis or test program, closure of lower level requirements				

√	MR2-80-007	Launch Vehicle ERD Compatibility	Observatory shall be able to survive the launch vehicle (LV) environments		E	The Observatory is required to survive the launch loads, vibration, and acoustic environments of the LV with no degradation to alignments and deployables.		A			T	A, T - Instrument, Spacecraft and Observatory environmental analysis or test program, closure of lower level requirements				
√	MR2-80-008	Operational Readiness Test Support	Spacecraft bus and payload teams shall support Operational Readiness Tests (ORT) and mission simulations		F	Defines support of both teams for ORT and simulations				I		Inspect both teams are involved				
√	MR2-80-009	Ground Handling Structural Environment	Observatory shall be able to handle environments generated from integration, testing and transportation activities		E	Such environments need to be evaluated since they could be worse that actual flight environments		A			T	A, T - Instrument, Spacecraft and Observatory environmental analysis or test program, closure of lower level requirements				
√	MR2-80-010	Satellite On-Orbit Environment	Observatory shall be able to handle on-orbit environments without unacceptable degradation of performance		E	The Observatory is required to survive the thermal transient loads and radiation environments of the on-orbit operation with no degradation to alignments, deployables, and avionics for the duration of the nominal mission timeline		A			T	A, T - Instrument, Spacecraft and Observatory environmental analysis or test program, closure of lower level requirements				
√	MR2-80-011	Bus Team Support for Deployer Integration	Spacecraft bus team shall provide any required support to integrate and test launcher/dispenser with the manifested Launch System		F	Defines bus team support during integration and test to the deployer		A			T	A, T - Instrument, Spacecraft and Observatory analysis or test program, closure of lower level requirements				
√	MR2-80-012	GSE Support for Deployer Integration	Spacecraft bus team shall provide any necessary GSE support of LV integration		F	Defines bus team GSE support during LV integration		A			T	A, T - Instrument, Spacecraft and Observatory analysis or test program, closure of lower level requirements				
√	MR2-80-013	GSE Support for Environmental Testing	Spacecraft bus team shall provide any necessary GSE support for environmental testing		F	Defines bus team GSE support during environmental testing		A			T	A, T - Instrument, Spacecraft and Observatory analysis or test program, closure of lower level requirements				
√	MR2-80-014	Thermal Model Correlation	Spacecraft bus team shall correlate environmental testing thermal results with thermal models		F	Thermal analysis is used to make predictions for environmental testing. Some form of thermal balance will have to be done to validate thermal model used for predictions.		A			T	A, T - Instrument, Spacecraft and Observatory analysis or test program, closure of lower level requirements				
√	MR2-80-015	Bus Team Support for I&T	Spacecraft bus team shall support FSW and Observatory level testing		F	Defines bus team support during integration and test of the flight software and Observatory		A			T	A, T - Instrument, Spacecraft and Observatory analysis or test program, closure of lower level requirements				
√	MR2-80-016	GSE Support for Observatory Integration	The spacecraft bus team shall provide any required GSE necessary for Observatory integration		F	Defines bus team GSE support during observatory integration		A			T	A, T - Instrument, Spacecraft and Observatory analysis or test program, closure of lower level requirements				
√	MR2-80-017	MOI Test	Stowed and deployed moments of inertia tests shall be perform to the observatory		F	Make sure MOI complies with launcher requirements and to validate GNC assumptions for MOIs		A			T	A, T - Instrument, Spacecraft and Observatory analysis or test program, closure of lower level requirements				
√	MR2-80-018	TVAC Bakeout	Observatory shall be subjected to a TVAC bakeout, high temperature preffered		E	Bakeout is part of the contamination requirements for HaloSat. High temperature is preferred.		A			T	A, T - Instrument, Spacecraft and Observatory analysis or test program, closure of lower level requirements				
√	MR2-80-019	High Temp Bakeout	If selected,high temperature bakeout shall be at a temperature of 70 degrees C and vacuum < $1.0x10^{-5}$ Torr for a minimum of 3 hours		E	Defines high temperature bakeout for MR2-80-018		A			T	A, T - Instrument, Spacecraft and Observatory analysis or test program, closure of lower level requirements				
√	MR2-80-020	Low Temp Bakeout	If selected, low temperature bakeout shall be at a temperature of 60C and vacuum < $1.0x10^{-5}$ Torr for a minimum of 6 hours, lower bakeout temperature requires approval from HaloSat PM		E	Defines low temperature bakeout for MR2-80-018		A			T	A, T - Instrument, Spacecraft and Observatory analysis or test program, closure of lower level requirements				
√	MR2-80-021	Limited Performance Test	A limited performance and/or aliveness test to check critical items basic parameters shall be performed during I&T before and after activities which includes but is not limited to vibration test per axis		E	This test is the first line of checks to see if all components are alive and responding, not necessarily testing performance. It is useful as a first check after shipping, vibration and storage period among others.		A			T	A, T - Instrument, Spacecraft and Observatory analysis or test program, closure of lower level requirements				
√	MR2-80-022	Error Free Operations	The observatory shall operate error free for a minimum of 100 hours accumulated before launch including error free TVAC operations		E	Accumulation can include TVAC and ambient testing. If an error is detected/observed/identified, the counter restarts		A			T	A, T - Instrument, Spacecraft and Observatory analysis or test program, closure of lower level requirements				
√	MR2-80-023	TVAC Testing	Observatory qualification shall include TVAC testing		E	TVAC testing simulates orbit environment and is part of the environmental program		A			T	A, T - Instrument, Spacecraft and Observatory analysis or test program, closure of lower level requirements				
√	MR2-80-024	TVAC Testing Vacuum	TVAC testing shall be performed at a 10^{-5} Torr pressure or lower		E	Maximum pressure allowed for TVAC		A			T	A, T - Instrument, Spacecraft and Observatory analysis or test program, closure of lower level requirements				
√	MR2-80-025	TVAC Testing Temperature Range	TVAC testing temperature range shall be the hot predicted extreme plus 10°C and cold predicted extreme minus 10°C with the goal of reaching the hot and cold qualification temperatures of the components		E	Temperature range will depend on temperature predictions		A			T	A, T - Instrument, Spacecraft and Observatory analysis or test program, closure of lower level requirements				
√	MR2-80-026	TVAC Testing Deployments	TVAC testing shall include deployment testing if so equipped at cold and/or hot extreme (plus/minus 10°C), whichever is worst case for the deployable		E	TVAC deployments are typically done at cold extremes but it will depend on deployable design		A			T	A, T - Instrument, Spacecraft and Observatory analysis or test program, closure of lower level requirements				
√	MR2-80-027	TVAC Testing Cycles	TVAC testing shall include a minimum of 4 thermal cycles		E	Need to expose satellite to stress due to thermal cycling		A			T	A, T - Instrument, Spacecraft and Observatory analysis or test program, closure of lower level requirements				
√	MR2-80-028	TVAC Testing Plateaus	TVAC testing plateaus (hot and cold) shall by held for a minimum of 1 hour		E	Plateau used to make sure all or most of the observatory reached the extreme temperature		A			T	A, T - Instrument, Spacecraft and Observatory analysis or test program, closure of lower level requirements				
√	MR2-80-029	TVAC Testing Transition Rates	TVAC testing transition rates used shall be representative of on-orbit predictions		E	Rates should be fast to stress the observatory but representative to the space environment it will see based on predictions		A			T	A, T - Instrument, Spacecraft and Observatory analysis or test program, closure of lower level requirements				
√	MR2-80-030	TVAC Testing Starts	Observatory shall be subjected to a minimum of 1 hot start and 1 cold start		E	Hot and cold starts will show the satellite can recover from a power cycle at extreme temperatures		A			T	A, T - Instrument, Spacecraft and Observatory analysis or test program, closure of lower level requirements				
√	MR2-80-031	TVAC Testing Comprehensive Test	Observatory shall be subjected to a comprehensive test at different plateaus and during transitions		E	All parts of the observatory shall be exercised during all temperature conditions to make sure it can survive such environments.		A			T	A, T - Instrument, Spacecraft and Observatory analysis or test program, closure of lower level requirements				
√	MR2-80-032	TVAC Testing Error Free Operations	TVAC testing shall include a minimum of 40 hours of error free operations which include a minimum of 10 hours at hot plateau, 10 hours at cold plateau and 10 hours during transition		E	If an error is detected/observed/identified, the counter restarts		A			T	A, T - Instrument, Spacecraft and Observatory analysis or test program, closure of lower level requirements				